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## Cladoniae in the range of the Torrey Botanical Club

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This is an attempt to list and describe the species of the interesting and often beautiful lichen genus, *Cladonia*, which have been found or which may be looked for, in the range of the Torrey Botanical Club, covering New Jersey, eastern Pennsylvania, Long Island, and the Hudson Valley in New York as far north as the northern Catskills.

This treatment of the subject is offered for beginners, who, like the writer, have become interested in lichens, and for whom there is yet little available in the way of popular guides such as exist for flowering plants, ferns and mosses. This lack of guides has prevented inclusion of lichens in the usual forms of outdoor nature study. Study of lichens seems to have lagged behind that of other plants in the United States, and the number of specialists in lichens is small.

Recent appearance, in scientific journals, of more accessible literature, has stimulated interest in lichens, and it is to be hoped that before long, some well-illustrated guidebook, similar, for example, to Dr. A. J. Grout's "Mosses with a Hand Lens," will appear. Mrs. Gladys P. Anderson, of Rahway, N. J., a member of the club, has been working for years on such a book, and it is hoped it may soon appear. The writer owes largely to Mrs. Anderson his introduction to the study of lichens, as well as unfailing aid in their identification. He also owes thanks to Dr. Alexander W. Evans, of the Osborn Botanical Laboratory, Yale University, for many kindnesses in identifications and encouragement in this field of botany. Dr. Evans' monograph on "The Cladoniae of Connecticut," is the most thorough treatment of this genus for the eastern United States. It was first published in the Transactions of the Connecticut Academy of Sciences, in 1930, and later as a reprint, by the Yale University Press. A revision of his list of species with

several additional ones, and clearer definition of others, was published by Dr. Evans, in *Rhodora*, the journal of the New England Botanical Society, in the issue for July-August, 1932.

As Dr. Evans points out, while his monograph and notes are based on species collected in Connecticut, they are useful in the determination of species from other regions. Dr. Evans has kindly read the proof of this article and made many suggestions for its improvement.

We have also found useful, and a model for this preliminary treatment of the *Cladoniae* of our range, a paper published in the July, 1931, issue, of *Rhodora*, on "Cladoniae in the District of Columbia and Vicinity," by C. A. Robbins and S. F. Blake, with a key and illustrations.

These two treatments of our eastern *Cladoniae* are the only recent ones at present easily available, the only others being that of Professor Edward Tuckerman, of Amherst College, our earliest American lichenist, in his "North American Lichens," published in 1880, long out of print and rare; and in Prof. Bruce Fink's "The Lichens of Minnesota," published in 1910, by the Smithsonian Institution, also out of print and hard to obtain. Prof. Fink also published a number of articles on species of *Cladonia* in early numbers of the *Bryologist*, journal of the Sullivant Moss Society, between 1903 and 1908, with excellent illustrations, but gathered together all of his data on the genus in the bulletin on the lichens of Minnesota, which is serviceable in many respects for the lichens of the eastern states as well. Reference should also be made to Nina Marshall's "Mosses and Lichens," (Doubleday) with good illustrations but it too is out of print.

The nomenclature of the works of Tuckerman and Fink has been superseded by modern reclassification in many cases, and the new names for *Cladoniae* are found in the papers of Dr. Evans and of Robbins & Blake. The scarcity of lichen guides in English and the lack of anything of the sort for our club range, other than Dr. Evans' treatment for Connecticut, has moved the writer to offer this preliminary treatment of the *Cladoniae* of our immediate region.

Since this paper is offered for beginners, a brief account of the morphology of lichens and of the genus *Cladonia* may be in order. Using as our authorities here Annie Lorain Smith's

"Lichens," in the Cambridge University Botanical Series, and the introduction to Bruce Fink's "Lichens of Minnesota," it may be stated that after three centuries of varying ideas as to the real nature of lichens, it is now generally accepted that they are dual in nature, a symbiotic association of algae and fungi. Symbiosis (living together) is found in other forms of plant life, but nowhere else in such an extensive, intimate and efficient a manner as in lichens. Schwendener, who first definitely propounded the idea of lichen symbiosis, in 1860, regarded the relation of the fungus as that of a parasite upon the alga, though not a deadly one, and expressed this in the following picturesque language.

"All these plants are not individuals in the common sense of that term; they are rather colonies, consisting of hundreds and thousands of individuals, of which one holds the mastership, while the others in eternal captivity prepare the nourishment for themselves and their masters. The Master is a Fungus of the Class of Ascomycetae, a parasite which lives on the labor of others; its slaves are green Algae, which it seeks or lays hold of and forces into its service. It encloses them, as a spider its prey, with a network of delicate tissue, which is gradually transformed into an impervious integument. But while the spider sucks the life out of its prey, the Fungus stimulates the Algae in its grasp to greater activity, to a more vigorous increase, and thereby renders possible a luxuriant growth and promotes the welfare of the whole colony."

There has been much discussion since Schwendener's time as to whether the association is parasitic or mutually beneficial. Reinke suggested the term "Consortium" as expressing his idea that the symbiosis was a state of mutual growth and interdependence, in which the algal cells produced food products from the substratum, or the air, enabling the fungal cells to develop into their often beautiful and complicated fruiting structures, which produce spores that germinate only if they find within a very brief time after dispersal free algal spores of species similar to those which the parent lichen had in partnership.

That lichens renew themselves in this manner, as well as in others to be referred to later, is proved by the fixity of genera from very ancient geological periods (at least as old as the

Devonian), and by the production of "synthetic lichens," in the laboratory by European experimenters, where lichen spores, sowed upon suitable algal cells, in culture media have germinated into lichens resembling the parents. Readers are referred to Annie Lorain Smith's book for a very full account of the history of the development of knowledge concerning lichens. Her two volume "British Lichens," is also valuable for identification of many cosmopolitan species found in both the old and new worlds. A condensed edition is also available.

To place the Cladoniae, it may be said that lichens in general are of three kinds; crustose, growing closely upon rocks, bark or earth; such as *Lecidea albocaerulescens*, to name a common species in our range, with bluish-gray thallus looking almost as if painted on rock; foliose, leaf-like, such as the familiar Rock Trips, or *Parmelias*; and fruticose, shrublike or branching, of which the Cladonias, and especially such densely branching forms as the "Reindeer Mosses," are typical examples.

A Cladonia plant is usually erect, with distinct stems, simple or branched, and often with conspicuous fruit, to use an easily understood term; such as, for example, the familiar Scarlet-crested Cladonia, occurring everywhere in our range, and one of the first lichens to attract the attention of young nature students, because of its brilliant color. In height Cladonias range from tiny species like *C. papillaria*, *mitrula*, *brevis* and *cariosa*, 1/4 to 1/2 inch tall; to *C. gracilis* and *C. rangiferina*, three or four inches tall in our range, and the latter a foot high in northern regions. In area colonies sometimes cover several acres.

To be more precise in terms, the Cladonia plant usually shows two distinct parts, the primary thallus, of scale-like leaves, from a size no larger than the head of a pin to an inch long in different species, prostrate or somewhat raised, sometimes densely aggregated into a crust; and the podetium, the erect portion on which the apothecia, or spore-producing organs, are borne. The podetium is regarded as a sort of secondary thallus.

Both primary thallus and podetia contain algal cells, just under the surface, spherical and bright green when moist, which are usually identified as in the genus *Cystococcus*. They are enmeshed by the hyphae, thread-like processes extending from

the fungal coat of the lichen inward, (to be seen only under a high power microscope). This leathery coat is very thin, and in some species is absent, when the podetium is described as decorticate, and may be covered by powdery granules, known as soredia. When moist the green algal cells show through the transparent fungal envelope, when present, and make the whole plant much more conspicuous and handsome than when it is dry, when the color is much duller. The decorticate forms are whitish looking whether wet or dry. But all show up much more plainly when moist, so that a rainy day is a good day to pursue Cladonias. When the plants are badly weathered, by long covering under snow and ice in winter, or by a summer drought, their appearance is much changed and they are more difficult to identify, though if not too much affected by such experiences, wetting will restore them to fullness and make their characters clearer for study.

The podetia, which give the most useful characters for classification for the beginner, are densely branching, as in the "Reindeer Mosses" and the Unciales (see key); short branched, as in some of scarlet-fruited species; simple and unbranched in others, and in some species bear cups ("Fairy Cups" of children), which may be simple and sterile or may bear apothecia, on the cup rims or on branches which in some cases may be quite complicated, with or without squamules (scaly leaves), as in forms of *C. squamosa*; or the cups may be in ranks of two to five, growing out of the rims, as in *C. gracilis*; or out of the middle of the cups, as in *C. verticillata*.

Cladoniae reproduce in the three ways found in lichens, by spores, by soredia, and by fragmentation. Reproduction by spores produced in the apothecia, while most interesting, as corresponding somewhat to the methods of mosses, hepaticas and ferns, is probably the least certain. The lichen spore, by reason of the long habituation of the plants to symbiotic association between certain fungal and algal species, must find, within a brief time after dispersal, and within a small area about the parent plant, free algal cells of the species with which the lichen fungus concerned has established symbiosis. The chances against such conjunctions must be very great, but the spores are produced in large numbers and contact is evidently established frequently enough to make the process sufficiently effec-

tive. It is probable that evolution is still going on and new associations and what man calls new species are still being developed.

The second method is surer. The soredia are granules containing both fungal and algal cells borne on the thallus or podetium. As the thallus and podetium mature, or regenerate after drying out or weathering, soredia develop on the surfaces. These gradually loosen and fall off, and may roll or be blown by the wind or carried by insects or animals for some distance. Timely moisture and a temperature above freezing are all they need to start new colonies, which in time will develop perfect lichens, bearing apothecia. Most reproduction of *Cladoniae* is probably effected by this method.

Fragmentation, by the drying out and breaking up of lichen thalli, occurs in large foliose species, such as *Parmelia*, and if fortunate wetting by rain or dew occurs soon after scattering of such fragments, they may start new colonies, as the soredia do. Occasional reproduction of *Cladoniae* may occur in this manner.

The genus *Cladonia* is divided, according to the arrangement now generally used, which was adopted by Professor Edward August Vainio, the distinguished Finnish authority, into three subgenera: *Cladina*, including the "Reindeer Mosses;" *Pycnothelia*, with the single species *C. papillaria*, short, simple forms; and *Cenomyce*, with foliaceous primary thallus, which the first two subgenera lack, including a great variety of species. The Latin names must be used here, for few lichens have common names, and students should learn the scientific names in the beginning, for with an understanding of the meanings of the Latin and Greek roots, from which the specific titles were framed (except in the cases of some honorific names), their fitness and accuracy will be appreciated. The botanists of the Eighteenth Century who studied lichens often showed a keen appreciation of outstanding characters and some of their specific names have survived for two centuries. If the student is unfamiliar with Latin and Greek, the meanings of the roots of the specific names may be found in such works as Jackson's *Botanical Dictionary*.

An interesting method of determining the precise identity of a number of species of *Cladonia* is by the application of

strong solutions of potassium hydroxide (KOH) or calcium hypochlorite to the squamules or podetia. It works best on the back of primary squamules. A prompt and often striking color reaction is obtained, through the effects of these alkalis upon the acids in the lichen thallus. The solutions may be obtained from a druggist or the chemicals may be purchased and solutions made at home; an old iodine dropper bottle is a good container. In some cases where other characters may not be positive, a species may be accurately determined by the yellow, red or brown color changes. In the key, KOH+ means that a reaction occurs; KOH- that it does not; and  $\text{CaClO}_2$  is noted in the same way.

#### Key to Groups and Species

Subgenus 1. CLADINA (Nyl.) Vain. Primary thallus crustaceous, soon disappearing, rarely seen. Podetia slender, one to four inches tall in the species in our range, much branched, arachnoid-tomentose, (like a spider's web, or with fine down like hairs) without cortex (Latin bark or rind) or distinct outer layer, except a "pseudo-cortex" of scattered or contiguous warty excrescences, gonidia, green algal cells; tips of branches with two to eight minute forks, usually brownish; apothecia small, circular, rarely seen. The species in this subgenus are usually densely massed and tangled together, often in large colonies, and two or more species are often found together in the same colony. Terminal apices blunt. They are known generally as "Reindeer Mosses," because they are the principal food of reindeer in countries near the Arctic Circle, such as Lapland, northern Scandinavia, northern Russia and Siberia, and the support indirectly of several millions of human beings who depend for food and clothing upon the reindeer. They are generally of a grayish, or grayish green color, but may be brighter green in the shade, or sometimes olive-tinted and are recognizable from species of other subgenera from their massed, entangled habit. (Species of *C. furcata* are also entangled but otherwise different.) They have been used for human food, being ground up with rye or other cereal flour, and this mixture is said to be nourishing and tonic in effect.

Podetia in dense, irregularly entangled colonies

Podetia often polytomous (many-branched) with whorls of three or more branches surrounding gaping axes; outer podetal layers persistent.

Podetia ashy-gray, darker in old plants; or sometimes brownish or greenish; surface arachnoid, KOH+, yellowish. (Pl. 1, f. 1.)

1. *C. rangiferina*.

Podetia yellowish-green, varying to gray, whitish or greenish; usually more delicate than *C. rangiferina*; KOH-. Podetia straw-colored, or greenish or grayish, with frequent sub-secund (on one side) branches between the whorls of branches on the main axes, outer branches often curving in one direction, apices nodding, with tips

3-8 pointed; gonidia grayish, greenish or brownish; interspaces tomentose. 2. *C. sylvatica*.

Podetia sometimes whorled throughout along the main axes, or with occasional single branches between whorls; peripheral branches upright, or in older plants, curving or nodding, with ultimate branches in clusters of three or more, sometimes distinctly parallel; podetial surface smooth, or in older plants verruculose (with minute warts). (Pl. 1, f. 3.) 3. *C. mitis*.

Podetia rarely polytomous (many-branched) and usually dichotomous (branching by two forks) or occasionally with single branches on one side; straw-colored, greenish, whitish or brownish.

KOH+, pale yellow, outer podetial layers persistent, monopodial (single stemmed) appearance clear in larger axes; podetial surface smooth, or verruculose in older plants. (Pl. 1, f. 2.) 4. *C. tenuis*.

KOH-, monopodial appearance not so definite, podetia irregularly branched or subdichotomously divided, podetial surface rough with disintegrating gonidia as plant matures, gonidia greenish, yellowish or whitish, or darkening. 5. *C. impexa*.

Podetia in regular, smooth, compact colonies, plant masses often with an even, curving top, the podetia being all of nearly equal length; polytomous (many-branched); with whorls of branches around gaping axils; whitish or pale gray; KOH-, outer podetial layers often disintegrating—surfaces arachnoid. Characterized in appearance, by the smoothly rounded masses; children call them "biscuits," or "castles" in New England. 6. *C. alpestris*.

Subgenus 2. PYCNOTHELIA Ach. Primary thallus granular-crustaceous; persistent. Podetia short,  $\frac{1}{8}$  inch to one inch tall; stout, simple, or short-branched, terminating in blunt tips. Apothecia small, brownish-red. The single species in this sub-genus is in strong contrast, in its simple forms, to those of the previous division. It resembles, as Robbins and Blake note, "minute cacti," a fact brought out well with a hand lens. Forms described in notes on habitats. (Pl. 1, f. 4.) 7. *C. papillaria*.

Subgenus 3. CENOMYCE. (Ach) Th. Fr. Primary thallus foliaceous (with leaf like squamules) persistent, or sometimes disappearing.

Series A. COCCIFERA Del. Apothecia scarlet, or rarely flesh-colored or whitish in some color forms. This series includes some of the most conspicuous and well known species of Cladonia. The brilliant color of their fruit, especially in the common *C. cristatella*, has given them popular names, such as "Scarlet-Crested Cladonia," "British Soldiers," "Red Tops," etc. They are among the most striking and beautiful of lichens.

a. SUBGLAUCESCENTES Vainio. Primary squamules grayish-green above, white beneath; podetia whitish to grayish green; podetia sometimes fertile, with rather small scarlet apothecia, or sterile, with blunt or pointed apices, mostly decorticate, (without a definite outer cortex or skin), and the decorticate areas farinose-sorediate, or granulose.

Podetia usually basally corticate, but with cortex discontinuous above, especially below the apices. KOH-. (Pl. 1, f. 7.) 8. *C. Floerkeana*.  
 Podetia sometimes basally corticate, but above wholly decorticate and farinose-sorediate. KOH-. (Pl. 1, f. 6.) 9. *C. bacillaris*.  
 KOH+ (yellow). (Pl. 1, f. 10.) 10. *C. macilenta*.  
 Podetia first covered with scattered or crowded squamules, or granules, interspersed with fine soredia, both later disappearing, leaving the medulla exposed. KOH-. (Pl. 1, f. 8.) 11. *C. didyma*.

These four species look much alike on casual observation and often grow together, but close examination with a lens, and application of potassium hydroxide will bring out their distinctions. In height they run from  $\frac{1}{2}$  inch or less to 1-2 inches. *C. Floerkeana* is often stouter than the other three, gives no reaction with KOH and the often dense cover of soredia almost buries the small scarlet apothecia on the tips, so that they can be seen only by looking down vertically upon the tops of a colony. *C. bacillaris* is usually more slender, taller, and often has quite conspicuous apothecia, usually single and terminal, bulging beyond the diameter of the podetium. Some podetia branch at the tips. *C. macilenta* is much like *bacillaris* with apothecia often deeply covered by soredia, and occasionally branching podetia, but is distinguished by the prompt yellow reaction with KOH, lacking in *C. bacillaris* and *Floerkeana*. *C. didyma* might be taken, at first sight to be a stunted form of one of the other three, but the presence on young plants of podetial squamules or granules distinguishes it, and also, in favorable locations, a dense, even-topped habit of its colonies, less scattered than the other three.

b. STRAMINEO-FLAVIDAE Vainio. Primary squamules yellowish-green above, white or yellowish beneath; podetia yellowish-green.  
 Podetia cup-forming, sterile or fertile, (CaCl) KOH+, pale yellow. Cortex persistent, not sorediate. 12. *C. coccifera*.  
 Cortex disintegrating, usually sorediate. KOH-,  $\frac{1}{4}$  to 1 inch tall. (Pl. 1, f. 11.) 13. *C. pleurota*.  
 Cortex continuous or rimose (chinky), lower part sometimes squamulose, cortex often yellow-sorediose, margins of cups often irregularly dentate or proliferate, podetia tallest of our red fruited Cladoniae, sometimes 3 inches or more high. KOH-. (Pl. 1, f. 9.) 14. *C. deformis*.  
 Podetia not cup-forming, always terminated by apothecia; cortex continuous, or areolately dispersed, or absent. KOH-.  
 Plants not sorediate; podetia variously branched in several different forms—described in habitat notes—decorticate areas whitish, arachnoid. (Pl. 1, f. 5.) 15. *C. cristatella*.  
 Plants more or less sorediate, sometimes densely so, podetia simple, club shaped, decorticate areas naked; in large, well-fruited, dense colonies apothecia tend to face one way, so that one sees a red color looking at the plants one way, and a greenish yellow color

when looking at them in reverse. Podetia often squamulose, sometimes naked; in extremely squamulose forms the apothecia are degenerate in size, or even wanting, and the podetia are densely clad in small squamules. (Pl. 1, f. 12.) 16. *C. incrassata*.

Series B. OCHROPHAEAE. Vainio. Apothecia brown to flesh color.

a. **UNCIALES.** (Del) Vainio. Primary thallus foliose, disappearing, seen only in young plants. Podetia not persistent at base, cylindrical or irregularly swollen, corticate (except in *C. Boryi*), never squamulose, becoming much branched and intertwined; cortex usually smooth and shining (except in *C. Boryi*), *apices spinose*, which distinguish the species in this group from the Cladinae, which they resemble in the massed habit. The Unciales further differ from the Cladinae in the conspicuous, smooth cortex (with the exception noted), the latter being rough surfaced. One to four inches high.

Podetia smooth and firm on surface, yellowish gray to brownish green, with axillary or internodal perforations conspicuous in older plants, both sterile and fertile; cupless. (Pl. 2, f. 1.) 17. *C. uncialis*.

Podetia smooth, yellowish gray to pale yellowish green, occasionally with shallow cups, axillary perforations rare on sterile plants, found on fruiting plants; more diversely branching than last. (Pl. 2, f. 2.) 18. *C. caroliniana*.

Podetia delicate in surface, tending to be decorticate, dull ashy gray, sometimes quite stout, up to 8 millimeters in diameter, older plants with reticulate or perforated surfaces and bearing large and distinct cibrose (latticed) cups; axillary perforations numerous. (Pl. 2, f. 3.) 19. *C. Boryi*.

b. **CHASMARIAE** (Ach). Floerke. Primary squamules persistent or disappearing, white beneath. Podetia usually persistent basally, *cupless or with open cups*, not closed by a diaphragm, axils usually open.

Primary squamules large, with entire or sinuate margins, podetia absent, apothecia rare, sessile on the primary squamules. KOH + faint yellow. 28. *C. apodocarpa*.

Primary squamules largest of any species here described, with broad, rounded lobes, with stout branching podetia, subulate-tipped, and sterile, or bearing small cups, simple or proliferous, rather rarely fruiting, faint yellow reaction with KOH. (Pl. 3, f. 6.) 29. *C. turgida*.

Primary squamules small to medium, with finely incised to crenate marginal divisions.

Podetia reduced to short stalks bearing apothecia, or the apothecia sessile on the primary squamules. KOH -. (Pl. 3, f. 5.)

26. *C. caespiticia*.

Podetia well developed.

Podetia cup-forming, cups sometimes very small, in other forms well developed and densely branching; cortex disintegrating. KOH -. (Pl. 2, f. 5.) 24. *C. squamosa*.

Allied to *C. furcata*, but distinctive in producing cups with punctured or lacerate closing membrances, and proliferations which sometimes bear cups. KOH -.

22. *C. multiformis*.

Primary squamules smaller than in last three species, podetia bearing cups with no or very slight closing membrane, or cupless. KOH - . (Pl. 2, f. 7.) 23. *C. crispata*.

Podetia not cup-forming.

Plants very small, and delicate, on decaying wood; sorediate granulose, or granulose-squamulose, cortex dispersed or wanting, podetia short, simple or branched. KOH + yellow. (Pl. 3, f. 1.) 25. *C. delicata*.

Plants neither granulose nor sorediate, usually on earth.

Podetia short-branched, cortex areolate, apices obtuse, axils round-perforate. KOH + yellow. (Pl. 3, f. 2.)

27. *C. floridana*.

Podetia much-branched, branches often dichotomous, slender and elongated; cortex continuous or areolate; apices often subulate; axils irregularly gaping. KOH - . (Pl. 2, f. 4.) 20. *C. furcata*.

Like *C. furcata*, but sorediose. 21. *C. scabriuscula*.

c. CLAUSAE Vainio. Primary thallus persistent or disappearing; squamules white or creamy beneath. Podetia usually basally persistent, cupless, or with closed cups; axils closed. Podetia not intertwined, but growing by themselves. This series includes many cupped forms familiar even to the casual observer of lichens, known to children as "Fairy Cups."

Podetia cup-forming.

Plants neither sorediate nor granulose.

Cups regular.

Cups deep, usually with short marginal proliferations, cortex warty-areolate, with flat raised plates, or smooth. (Pl. 4, f. 3.) 37. *C. pyxidata*.

Cups shallow, 2 to 5 ranked, larger cups centrally proliferate, smaller cups toward margins or marginal, cortex smooth. (Pl. 4, f. 2.) 35. *C. verticillata*.

Cups as above, but with dense and rather large squamules on lower and sometimes upper ranks. (Pl. 4, f. 4.) 36. *C. calycantha*.

Cups shallow, broad or narrow, in 1 to 4 ranks, proliferate from the margins, cortex smooth. (Pl. 4, f. 1.) 34. *C. gracilis*.

Plants sorediose or granulose.

Cups irregular, shallow, one sided, with only one rank of proliferations, usually fertile. (Pl. 4, f. 7.) 39. *C. nemoxyna*.

Soredia farinaceous, squamules large with lobate margins, podetia subulate, or truncate, with small narrow cups. KOH + brownish. (Pl. 4, f. 6.) 40. *C. coniocraea*,

Same as above, but with subulate podetia more frequently bearing apothecia; cups when present as above but smooth inside. KOH + brownish. 41. *C. ochrochlora*.

Cups deep and often large, simple, or much varied by proliferations, with second ranks of cups or with ample apothecia. KOH -. (Pl. 4, f. 5.) 38. *C. chlorophaea*.

Cups shallow and small, irregular, or usually lacking and replaced by subulate apices which are often fertile. KOH -. 42. *C. pityrea*.

Podetia not cup-forming. Plants neither sorediate nor granulose.

Primary squamules minute, podetia simple or slightly branched and short with large apothecia or much branched with small apothecia. Cortex irregular or lacking. KOH -. (Pl. 3, f. 3.) 30. *C. mitrula*.

Primary squamules small, medium to large: podetia simple and club shaped, or with short branches.

Podetia grayish green to olivaceous, cortex continuous to areolate, surface sometimes flattened or depressed.

Primary squamules somewhat erect and densely crowded; podetia in one form densely squamulose. CaCl (KOH) + bluish green. (Pl. 3, f. 4.) 43. *C. strepsilis*.

Plants small, but stouter and more branched than above, KOH -. (Pl. 3, f. 7.) 31. *C. clavulifera*.

Podetia short and slender or stout. Obconic, usually somewhat branched, KOH + yellow, followed by brick red. (Pl. 3, f. 8.) 32. *C. subcariosa*.

Podetia short and usually simple, obconic, thickest just below apothecia, cortex fissured in small areoles, KOH -. (Pl. 3, f. 9.) 33. *C. brevis*.

#### Forms of species and habitat notes.

1. *C. RANGIFERINA* (L.) Web. (Pl. 1, f. 1.) In moss or thin soil over ledges, in the Highlands of New Jersey and southern New York, not very common; f. *CRISPATA* Coem., a smaller, densely intertwined, erect form, is sometimes found with the species.

2. *C. SYLVATICA* (L.) Hoffm. Occasionally found mixed with *C. rangiferina*, but not common; plentiful on Fire Island Beach, L. I.

3. *C. MITIS* Sandst. (Pl. 1, f. 3.) Common in eastern Long Island, covering large areas in open sandy places in Suffolk County: also on the New Jersey Pine Barrens: less frequent in the highlands.

4. *C. TENUIS* (Floerke) Harm. (Pl. 1, f. 2.) Occasionally found mixed with *C. mitis*, or sometimes in exclusive colonies,

preferring more shade than other Cladinae, in eastern Long Island, and in Pine Barrens; less common northward.

5. *C. IMPEXA* Harm. Reported by Dr. Evans in Connecticut, to be looked for in our range.

6. *C. ALPESTRIS* (L.) Rabenh. Found by this writer on North Mountain, in the northeastern Catskills at 3000 feet. Common in eastern and northern New England. Orient, L. I. (Roy Latham).

7. *C. PAPILLARIA* (Ehrh) Hoffm. (Pl. 1, f. 4.) Common, in the New Jersey Pine Barrens, in eastern Long Island, and in barren, gravelly, or sandy places elsewhere in area covered, sometimes at high elevations, to above 2,000 feet in Shawangunks and Poconos. Occurs in three forms, of which f. *MOLARIFORMIS*, with relatively large, stout and much branched podetia is commonest; f. *PAPILLOSA*, with small papilliform podetia, fairly common in arid or exposed places, from sea level to 2,000 feet; and f. *STIPATA*, with sterile, densely papillose upper branches, rarer, on high summits of Shawangunks and Poconos.

8. *C. FLOERKEANA* (Fr.) Floerke. (Pl. 1, f. 7.) occasionally mixed with *C. bacillaris* and *macilenta*, in moist woods, on earth or rotten wood, along New Jersey Pine Barren streams, or in low places on Long Island; less common in Highlands. Our usual form is var. *INTERMEDIA* Hepp, esquamulose; var. *CARCATA*, squamulose; and var. *SQUAMOSISSIMA*, densely squamulose, are recorded by Dr. Evans in Connecticut and may be looked for elsewhere in our range.

9. *C. BACILLARIS* (Ach.) Nyl. (Pl. 1, f. 6.) Never very plentiful in any one place, but widely distributed in our area, taller in moist places, dwarfed in thin soil over rocks in the highlands. Forms found by writer were f. *CLAVATA* (Ach.) Vainio, with blunt tipped podetia and f. *PERITHETA*, (Wallr.) Arn., with minute accessory apothecia on short lateral branches.

10. *C. MACILENTA* Hoffm. (Pl. 1, f. 10.) May be found with two previous species, but is rarer, and not readily distinguishable until KOH test is made, when yellow reaction determines it. In Pine Barrens and eastern Long Island, in the Catskills up to 2500 feet, probably elsewhere in our range. Our usual form is f. *STYRACELLA*, (Ach.) Vainio, with farinose soredia; other forms are *GRANULOSA* and *CORTICATA*.

11. *C. DIDYMA* (Fée) Vainio, (Pl. 1, f. 8.) related to and

somewhat resembling the previous three species, but usually smaller, primary squamules not sorediose, podetia first covered with squamules, or granules, and sometimes fine soredia, which later disappear, leaving the cartilaginous translucent surface; podetia simple or sparingly branched. Not rare in the Pine Barren swamps, on decaying wood; found in Wawayanda swamp, may be looked for in similar situations in northern part of our range.

12. *C. coccifera* (L.) Willd. This species was found by Robbins & Blake in Maryland, but not by Dr. Evans in Connecticut, up to 1932. It is listed to suggest that students look for it, most likely in sandy loam, probably near the coast, in our range.

13. *C. pleurota* (Floerke) Schaer. (Pl. 1, f. 11.) This handsome species, with red apothecia on the rims of bright green sorediose cups, has been found by the writer at several points in our range, most commonly in eastern Long Island, but never much of it in one spot. One may think he has found the rarer *C. coccifera*, but *pleurota* differs in being sorediose, while *coccifera* is smooth. Our usual form is f. *decorata* (Vainio) Evans, with short podetia, and often rather large red apothecia sessile on the margins. Var. *frondescens*, with squamose podetia, is reported by Evans in Connecticut and may be found elsewhere in our range. f. *decorata* is sometimes found among *C. chlorophaea* and *C. squamosa* var. *levicorticata*, m. *rigida*, in eastern Long Island. Its cups are often sterile, when they might be taken for *C. chlorophaea* f. *simplex*, but its bright green color identifies it, *C. chlorophaea* being a duller green.

14. *C. deformis* (L.) Hoffm. (Pl. 1, f. 9.) This species has been found once by the writer in our range on Panther Mt. 3760 feet, in the Catskills. It is not reported by Evans in Connecticut, but is listed to encourage students to look for it. It is common in the Adirondacks and northern New England, in coniferous forests, above 2000 or 3000 feet. It may be among northern species of *Cladonia* and other lichens, which, as suggested by Mrs. G. P. Anderson, might be looked for on the higher and more remote Catskill summits, the general flora, of which, above 3500 feet, is largely that of the northern spruce-fir zone.

15. *C. cristatella* Tuck. (Pl. 1, f. 5.) One of the commonest, most brilliantly colored and well known of our Clad-

doniae, familiar to children and natural history students. Every where in our range, though richest in numbers in the sunny pine and oak woods of eastern Long Island and in the Pine Barrens. Large colonies are often found on dead wood in the Highlands. It climbs to 3700 feet in the Catskills. It is represented with us by the following forms. f. BEAUVOISII (Del.) Vainio, with smooth podetia and scarlet apothecia; f. OCHROCARPIA Tuck. similar but with buff apothecia; f. RAMOSA, Tuck. like *Beauvoisii*; but densely branched from the base; f. VESTITA, Tuck., with more or less densely squamulose podetia, sometimes quite stout, and with abundant and often large and conspicuous scarlet apothecia; f. SQUAMULOSA, Robbins, like *vestita*, but with flesh colored apothecia; f. PLEUROCARPA, Robbins, with scarlet apothecia on short, lateral branches; or sessile on the sides of the podetia; f. DEGENERATA Robbins, with scarlet apothecia on short, often decumbent apothecia; f. ABBREVIATA, Merrill, with almost or quite sessile scarlet apothecia on the primary squamules; Dr. Evans has reported f. SQUAMOSISSIMA, with the podetia densely covered with small compact squamules, in Connecticut and it may be looked for elsewhere in our area.

16. *C. INCRASSATA* Floerke. (*C. PALUDICOLA* of older authors.) (Pl. 1, f. 12.) A very handsome species, when well fruited, with densely crowded podetia. Limited to its favorite habitats, usually on rotten wood in swamps, though sometimes in drier places. Found along cedar swamp streams in the Pine Barrens, in Wawayanda Cedar Swamp, west of Greenwood Lake, and in low places on eastern Long Island. A form, f. SQUAMULOSA, Robbins, with podetia densely squamulose, occurs with the species.

17. *C. UNCIALIS* (L.) Web. (Pl. 2, f. 1.) Well distributed in our area, from a few feet above sea level in Long Island and the Pine Barrens to over 2,000 feet on the Shawangunk Mountain. Students are referred to Dr. Evans' "Notes on the Cladoniae of Connecticut," *Rhodora*, July-Aug., 1932, for detailed and revised treatment of this and the two following species and their forms. *C. uncialis* varies much in size and shades of brownish and yellowish green, from densely matted dwarf plants of exposed places in the highlands, to taller, more open, slenderer forms in Long Island and the Pine Barrens, but the pointed,

usually brownish tips of the ultimate branches distinguish it from the Cladinae, with which it is often intermixed. *F. DICRAEA* (Ach.) Vainio with subulate apices is our commonest form, and *f. OBTUSATA* (Ach.) Nyl. with blunt apices, occurs. Other forms, which this writer has not identified in our range, are described by Dr. Evans.

18. *C. CAROLINIANA* (Schwein.) Tuck. (Pl. 2, f. 2.) Resembles *C. uncialis*, and is found with it, especially in eastern Long Island and the Pine Barrens, but is less yellowish or brownish, is more densely branching, and the axils are closed, or almost wholly so, while the axils of *C. uncialis* are often open. There are also microscopic differences. When the two are seen together, in herbarium specimens or material identified in the field by one who knows them, the distinctions are obvious though not always easily described. *F. DILATATA*, rather tall and stout; *f. FIBRILLOSA*, with fine hairs on the tips; and *f. TENUIRAMEA*, a low growing, lax form, may be found on Long Island and in south Jersey.

19. *C. BORYI* Tuck. (Pl. 2, f. 3.) A very striking Cladonia when one comes to know it, often standing out in the midst of a dense colony of *C. mitis*, when its terminal, cibrose (lattice-like) cups are well developed, and distinguished by its stout podetia, sometimes 8 millimetres in thickness, and their ashy gray, weathered look. It has the most conspicuous cups of any of the Unciales. In pine woods on ground not recently burned over in eastern Long Island, on Napeague Beach, Montauk Point, and the New Jersey Pine Barrens. Apparently wanting in the highlands. *F. LACUNOSA* and *f. RETICULATA* have been identified by Dr. Evans in material collected by this writer on eastern Long Island.

20. *C. FURCATA* (Huds.) Schrad. (Pl. 2, f. 4.) A very variable species, fairly common throughout our area, in all sorts of situations, wet and dry, low and high, from a few feet above tide-water in eastern Long Island to 4,000 feet in the Catskills. Distinguishable by the loosely branching, often two-forked habit. Common forms are var. *RACEMOSA* (Hoffm.) Floerke, with smooth dull or bright green podetia; var. *PINNATA* (Floerke) Vainio, *f. FOLIOLOSA* (Del) Vainio, with squamulose (often quite large, dense squamules), podetia, and var. *RACEMOSA* *f. CORYMBOSA*, (Ach) Vainio, with green or sometimes olive-tinted po-

detia, and occasionally with small brown apothecia. Other forms, which may be looked for in our range, are described by Dr. Evans, in the Cladoniae of Connecticut and additional notes in *Rhodora*. This species is often taken by beginners to be one of the Cladinae, but is distinct from members of that subgenus, by its loose, sprawling, low spreading form of branching and its generally greener color, in contrast to the ashen tints of the Cladinae. Also, it often bears podetial squamules, which the Cladinae never do.

21. *C. SCABRIUSCULA* (Del.) Leight. (Pl. 2, f. 6.) This species resembles *C. furcata*, but is distinct in bearing soredia, which disperse with age, leaving the podetia whitish: Found by this writer in the Catskills, west branch Neversink Creek, at 2500 feet, but may occur elsewhere in our range.

22. *C. MULTIFORMIS* Merrill. Allied to *C. furcata*, but bearing cups of peculiar, variable form, with the membranes punctured or lacerate; sometimes with proliferations bearing cups or branched. Not common.

23. *C. CRISPATA* (Ach.) Flot. (Pl. 2, f. 7.) In *C. CRISPATA*, f. *DIVULSA*, recorded by Evans in Connecticut, there are cups with no or very slight closing membrane. *C. squamosa*, f. *levicorticata* may be mistaken for *C. crispata*, but the latter is smooth, the former usually squamulose. F. *DIVULSA* may be looked for in our range. F. *ELEGANS*, which is often densely squamulose, and cupless, occurs in eastern Long Island and perhaps elsewhere in our range.

24. *C. SQUAMOSA* (Scop.) Hoffm. (Pl. 2, f. 5.) An extremely varied species, with simple and complex forms. Its variations have led to the division of some forms into "modifications," represented by the abbreviation "m." But if one is unable to reduce a specimen into one of the forms and modifications given by Dr. Evans and by Robbins and Blake, he may call it simply "*C. squamosa*," and not be wrong, even if not precisely right. Immature or weathered specimens may be irreducible beyond the species. The commonest form in the sandy moraine hills in eastern Long Island and in the New Jersey Pine Barrens, is f. *LEVICORTICATA*, m. *RIGIDA*, Sandst., ranging from simple, stiff little cupped podetia, with rough cortex, to fantastically branching cups, with a maze of proliferations. F. *DENTICOLLIS* (Hoffm.) Floerke, and f. *PHYLLOCOMA* (Rabenh.) Vainio, or something

very like them, though the writer has often found it safest to call them simply *C. squamosa*, occur in the Hudson Highlands, and the Catskills where they grow very robust, up to three or four inches in height. Students who would determine all the possible forms in our range are referred to Dr. Evans' Monograph and Notes, and the Robbins and Blake paper.

25. *C. DELICATA* (Ehrh.) Floerke. (Pl. 3, f. 1.) A small, pretty species, on decaying logs and tops of stumps in woods, probably fairly common, but overlooked because so tiny. Occurs in Franklin Clove, N. J., and in Wawayanda Cedar Swamp, and probably in similar swampy woods elsewhere in our area. Represented in our range by f. *QUERCINA* (Pers.) Vainio.

26. *C. CAESPITICIA* (Pers.) Floerke, (Pl. 3., f. 5.) Fairly common on the ground among hardwoods, sometimes on logs, and once found by the writer ten feet high on a living red maple in Wawayanda Cedar Swamp. Probably overlooked because of the sessile, brown apothecia, much like the color of dead leaves.

27. *C. FLORIDANA* Vainio. (Pl. 3, f. 2.) Low, rather densely branching, not common, to be looked for in open, sandy woods, in the Pine Barrens and on eastern Long Island. Yellow reaction with KOH is helpful in identifying it.

28. *C. APODOCARPA* Robbins. Common in open hardwoods, often in quite large colonies; may be taken for some other *Cladonia* in an immature, unfruited condition, as its apothecia are extremely rare. Yellow reaction with KOH on the white undersides of the rather large squamules distinguishes it.

29. *C. TURGIDA* (Ehrh.) Hoffm. (Pl. 3, f. 6.) Not common. F. *SCYPHIFERA*, with small, flat cups, reported from Green Pond, N. J., by Leon W. Bowen; f. *CORNICULATA*, with large primary squamules and rather robust podetia, with olive-tinted subulate tipped branches, reported in Connecticut by Evans; occurs in Adirondacks and may be looked for in Hudson Highlands or Catskills.

30. *C. MITRULA* Tuck. (Pl. 3, f. 3.) On earth in old fields, woods, and banks along old woodroads, fairly common throughout our area, except in higher Catskills. The usual form is f. *IMBRICATULA* (Nyl.) Vain., with large brown apothecia, wider than the diameter of the podetia; with it sometimes occurs f. *PALLIDA* Robbins, with flesh colored apothecia; also f. *MICRO-*

CARPA, with small brown apothecia in compact clusters on terminal branches.

31. *C. CLAVULIFERA* Vainio. (Pl. 3, f. 7.) Not common, but to be looked for with *C. mitrula*, *brevis* or *strepsilis*, found by writer in eastern Long Island, Franklin Lake, N. J., and in Pine Barrens, as f. *NUDICAULIS* Evans; and f. *SUBVESTITA* Robbins, with squamulose podetia may be looked for in similar situations.

32. *C. SUBCARIOSA* Nyl., (Pl. 3, f. 8.) In old fields, or open woods, in sandy or clayey soil, widely scattered, numerous in some localities, elsewhere wanting; often occurring with *C. strepsilis*, *brevis*, *mitrula* and *papillaria*, in eastern Long Island; with *C. pleurota* and *verticillata* in Bear Mountain Park; usually as f. *EVOLUTA* Vainio, with smooth, stout, obconic podetia, or f. *SQUAMULOSA* Robbins, with squamulose podetia, less common. Forms not yet found by this writer, but possibly occurring in our range are f. *EPIPHYLLA* Robbins, with apothecia sessile on primary squamules, and f. *PALLIDA* Robbins, with flesh colored or whitish apothecia. *C. subcariosa* may be mistaken for some of the other low, brown fruited species, but application of KOH instantly determines it, with the immediate appearance of a dirty yellow color, followed within 15-30 seconds by a permanent brick red, the only *Cladonia* with this color reaction.

33. *C. BREVIS* Sandst. (*C. alpicola* of Dr. Evans' Monograph of the *Cladoniae* of Connecticut, but he prefers *brevis* in his later Notes in *Rhodora*). (Pl. 3, f. 9.) Very low, 1/4 to 1/2 inch with dark brown bulging apothecia, occasional in open sandy woods in Suffolk Co. L. I., perhaps also in the Pine Barrens.

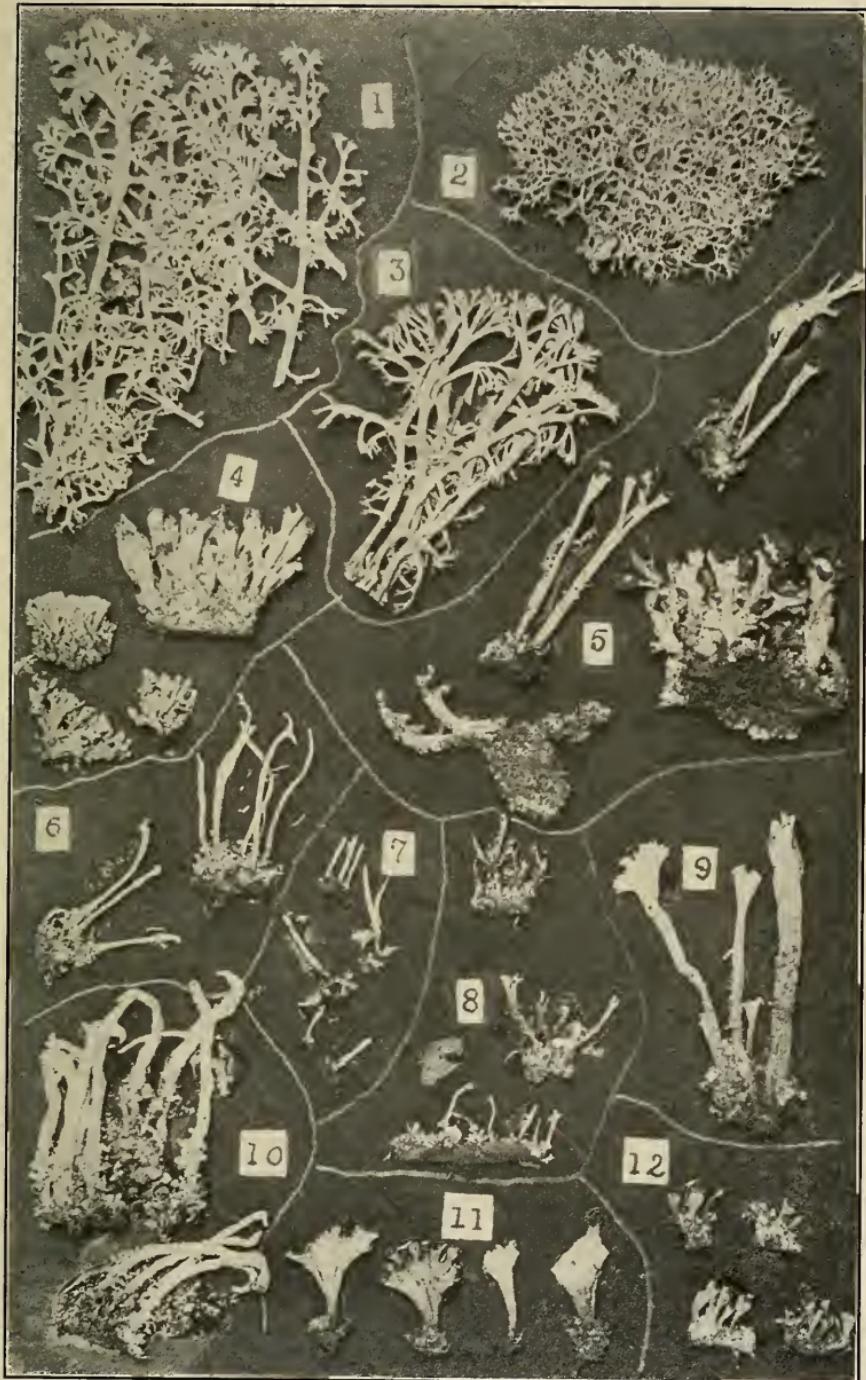
34. *C. GRACILIS* (L.) Willd. (Pl. 4, f. 1.) Common north of our range, in Adirondacks and New England, and occurring in the higher Catskills. Examples seen by or sent to this writer are var. *DILATATA* (Hoffm.) Vainio with stout, usually smooth podetia, but Dr. Evans reports in Connecticut, three forms of this variety, f. *ANTHOCEPHALA* (Floerke) Vainio, with squamulose podetia; f. *DILACERATA* (Floerke) Vainio, with irregular squamulose cups, and f. *SQUAMULOSA* (Schaer.) Sandst. squamulose below, sterile; also f. *CHORDALIS*, with slender, erect, cylindrical podetia, all of which may be looked for in the northern parts of our range, in the Catskills or Taconics.

35. *C. VERTICILLATA* (Hoffm.) Schaer. (Pl. 4, f. 2.) On the earth, along banks and old fields and open woods, edges of wood-roads, widely distributed but usually in small colonies. We have f. *EVOLUTA* (Th. Fr.) Stein., with smooth podetia, and central proliferations only; and f. *APOTICTA* (Ach.) Vainio, similar but with proliferations also from the sides of the podetia.

36. *C. CALYCANTHA* Vainio. (Pl. 4, f. 4) much like *C. verticillata*, but not quite as stout, and with dense, branching squamules on the lower, first or second ranks of cups; along the borders of streams and swamps in the Pine Barrens.

37. *C. PYXIDATA* (L.) Fr. (Pl. 4, f. 3.) As now limited to forms with deep cups, with raised flat green areoles, separated by whitish lines, or smooth; not sorediose, this species appears to be scarce in our area.

38. *C. CHLOROPHAEA* (Floerke) Spreng. (Pl. 4, f. 5.) This is *C. pyxidata*, f. *chlorophaea*, of Fink's "Lichens of Minnesota," (for the benefit of those who possess that valuable work), and of some older writers, but *C. pyxidata* is now restricted to the forms described under No. 38. As described by Evans, and Robbins and Blake, *C. chlorophaea* is one of the commonest Cladoniae in our area, rivalling *C. cristatella* in that respect. Some confusion has been introduced by the use of the name, *C. Grayi*, by Sandstede, for this species or something like it, which the German authority distinguishes by recording a mild taste, and chemical difference, as against other closely related cup-like forms. See Dr. Evans' Notes on the Cladoniae of Connecticut, Rhodora, August 1932, pages 159-160. After consultation with Dr. Evans, this writer has concluded to use *C. chlorophaea*, and ignore *C. Grayi*, for the present, as the former is more convenient for students, especially for the several forms which are clearly described in Evans' Monograph on the Cladoniae of Connecticut, Pages 465-472. Common forms in our area are: f. *SIMPLEX* (Hoffm.) Arn., with 1-ranked esquamulose sterile plants, with decorticate surfaces of cups smooth and opaque; f. *PROLIFERA* (Wallr.) Arn., like f. *simplex*, but with cups marginally proliferous, usually into a second rank of smaller cups; f. *PTERYGOTA* (Floerke) Vainio, sterile squamulose plants; f. *CARPOPHORA* (Floerke) Anders, esquamulose plants, with distinct cups bearing sessile or stipitate podetia, often with proliferations larger than the cups and with conspicuous apo-



CLADONIAE IN THE RANGE OF THE TORREY BOTANICAL CLUB

PLATE 1. Fig. 1. *Cladonia rangiferina*. Fig. 2. *C. tenuis*. Fig. 3. *C. mitis*. Fig. 4. *C. papillaria*, upper right a well developed specimen; lower right, younger; left, upper, f. *papillosa*; lower, tending toward f. *stipata*. Fig. 5. *C. cristatella*; upper and left specimens, f. *Beauvoisii*, right, with large apothecia, f. *vestita*, lower left, f. *squamosissima*. Fig. 6. *C. bacillaris*; specimen at right, f. *peritheta*. Fig. 7. *C. Floerkeana*. Fig. 8. *C. didyma*. Fig. 9. *C. deformis*. Fig. 10. *C. macilenta*, f. *stylaracella*. Fig. 11. *C. pleurota*, f. *decorata*. Fig. 12. *C. incrassata*.